Development and Validation of an Expedited 10g Protein Counter (EP-10) for Dietary Protein Intake Quantification

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ABSTRACT

Objective: Precise protein quantification is essential in clinical dietetics, particularly in the management of renal, burn and malnourished patients. The EP-10 was developed to expedite the estimation of dietary protein for nutritional assessment and recommendation. The main objective of this study was to compare the validity and efficacy of the EP-10 with the American Dietetic Association's "Exchange List for Meal Planning" (ADA-7g) in quantifying dietary protein intake, against computerised nutrient analysis (CNA).

Design: Protein intake of 197 food records kept by healthy adult subjects in Singapore was determined thrice using three different methods – (1) EP-10, (2) ADA-7g and (3) CNA using SERVE program (Version 4.0). Assessments using the EP-10 and ADA-7g were performed by two assessors in a blind crossover manner while a third assessor performed the CNA. All assessors were blind to each other's results. Time taken to assess a subsample (n=165) using the EP-10 and ADA-7g was also recorded.

Results: Mean difference in protein intake quantification when compared to the CNA was statistically non-significant for the EP-10 (1.4 ± 16.3 g, $P = .239$) and statistically significant for the ADA-7g (-2.2 ± 15.6 g, $P = .046$). Both the EP-10 and ADA-7g had clinically acceptable agreement with the CNA as determined via Bland-Altman plots, although it was found that EP-10 had a tendency to overestimate with protein intakes above 150 g. The EP-10 required significantly less time for protein intake quantification than the ADA-7g (mean time of 65 ± 36 seconds vs. 111 ± 40 seconds, $P < .001$).

Conclusion: The EP-10 and ADA-7g are valid clinical tools for protein intake quantification in an Asian context, with EP-10 being more time efficient. However, a dietician's discretion is needed when the EP-10 is used on protein intakes above 150g.

Keywords: Protein counter; Protein exchange; Protein intake; Dietary protein; Validation

Introduction

Precise protein quantification is essential for assessment and recommendation of dietary intake particularly in the management of renal, burns and malnourished patients. Dietary sources of protein can be classified into two main groups – (1) protein-rich or (2) non-protein-rich. A method commonly used by dieticians for dietary protein intake assessment and recommendations is the combination of the use of ideal or current body weight (to calculate an individual's protein requirements depending on medical condition) and the use of protein exchange lists.[1] Widely practised methods of protein intake estimation for assessment and prescription utilise protein exchanges of 7g for protein-rich foods (meat and meat substitutes), 3g for carbohydrates foods and 2g for vegetables.[1]

Exchange lists were first developed in 1950 by the American Dietetic Association, the American Diabetes Association, and the US Public Health Service for nutrition management in diabetes.[2] Primarily used to assess and develop diets for individuals with diabetes, it therefore focuses on carbohydrates.[2] This exchange list, called the American Dietetic Association's "Exchange List for Meal Planning,"[3] hereafter referred to as ADA-7 g, is updated regularly and remains the only published food exchange list available. Thus far, neither a published validation study conducted on the use of this exchange list for quantification of nutrient intakes, nor a published exchange list focusing primarily on protein, is available.

The EP-10 was developed to expedite the quantification of dietary protein for assessment and recommendation of protein intake. Instead of using separate protein exchanges for different food groups to quantify the dietary protein intake of an individual, every exchange in the EP-10 accounts for an exchange each of 3g non-protein-rich food and 7g protein-rich food.

Development of the EP-10

A cross-sectional study on 60 food records was conducted in the Year 2000 to investigate the proportion of dietary protein intake that comes from protein-rich foods (meats and meat substitutes, including dairy products) and non-protein-rich foods (starches and vegetables) in healthy adults. Results of this study (shown in Table 1) found that protein-rich foods provided approximately 70% of an individual's dietary protein intake while non-protein-rich foods made up the remaining 30%. This 30:70 proportion of non-protein-rich foods to protein-rich foods was then used to allocate estimated protein requirements in meal planning. In doing so, it was further discovered that the amounts of 3g and 7g protein exchanges required (for non-protein-rich and protein-rich foods respectively) were the same as dividing the estimated protein requirements by a factor of 10.

The combination of these two findings meant that dietary protein quantification and recommendations could be expedited and simplified using 10g protein exchanges. These 10g protein exchanges were then compiled to create the EP-10 list (Table 2). This EP-10 list, comprised of common protein-rich foods, was created using nutritional information extracted from the nutritional panel of local food items, the Singapore Food Composition Table [4] and the Nutrient Composition of Malaysian Foods.[5] A single exchange of EP-10 would account for a single exchange of protein-rich food and non-protein- rich food. By simplifying dietary protein quantification, the EP-10 potentially shortens the time needed for dietary assessment and recommendations in dietetic consultations where they are often required in the same sitting. However, its validity and efficacy for use in practice have not been determined.

Table 1. Mean energy and macronutrient intakes of a cross-sectional study done on 60 food records for the development of the Expedited 10g Protein Counter (EP-10).

Nutrient	**Mean ± SD**	**Mean energy contribution from each nutrient ± SD, %**
Energy, kcal	1964.9 ± 407.2	NA
Carbohydrate, g	264.1 ± 63.0	54.1 ± 9.6
Protein, g	87.3 ± 28.8	17.9 ± 5.3
- **Proportion from protein-rich foods**	63.6 ± 28.1	70.6 ± 11.2
- **Proportion from non-protein-rich foods**	23.7 ± 7.5	29.4 ± 11.2
Fat, g	68.5 ± 24.3	31.0 ± 7.7

Table 2. Equivalent of One exchange in the Expedited 10g protein exchange (EP-10)

FOOD ITEM	COOKED WEIGHT*	HOUSEHOLD MEASURE*
Meat, Poultry, Fish and Seafood		
Meat/Poultry/Fish	30g	Size of 1 matchbox 1/3 palm size
Chicken wing (without drumlet)	45g	1
Canned tuna flakes	30g	2 tablespoons
Prawns / Shellfish	30g	4 medium pieces
Squid balls / Fish balls	50g	4-5
Crabsticks	70g	4
Egg, whole	50g	1
Egg whites	50g	2
Chicken essence	70g	1 bottle
Vegetables		
Corn, on the cob	250g	1 big
Corn kernels / Sweet corn	200g	1.5 cups
Peas, fresh or canned	100g	¾ cup
Dairy products and substitutes		
Beverages		
- Cow's/Goat's Milk	200ml	1 glass
- Yoghurt drink	200ml	1 glass
- Soya bean milk	300ml	1.5 glasses
- Milo (ready to drink)	400ml	2 glasses, 1.5 packet
- Yoghurt drinks (eg: Yakult, Vitagen)	200ml	2 bottles
Evaporated Milk	90ml	6 tablespoons
Cheese slices	30g	1 slice
Yoghurt	125g	½ cup
Milk powder, cow's or goat's	30g	4 tablespoons
Milo powder (or other malted drinks)	60g	4 tablespoons
3-in-1 malted drinks sachets (eg: 3-in-1 Milo, Horlicks, Ovaltine)	90g	3 sachets
Beans, lentils and legumes		
Tofu/Beancurd (hard)	60g	½ square
Tofu/ Beancurd (soft)	90 g	½ square
Baked beans (drained)	140g	3 heaped tablespoons
Cooked lentils/beans (eg: Dhal, Mung bean, Red bean , Green bean, Kidney bean, Soy bean)	90g	3 tablespoons
Dry lentils (uncooked)	30g	2 tablespoons
Gluten/Mock Meat	50g	1/3 cup
Soyabean curd, with syrup	100g	½ cup
Seeds, Nuts and nut-based products		
Lotus seeds	80g	1/3 cup
Gingko nuts	162g	1 cup
Peanuts (Unshelled)	35g	27 unshelled peanuts 4 tablespoons
Almonds/ Peanuts / Other nuts	30g	2 heaped tablespoons
Cashew nuts	45g	3 ½ heaped tablespoons
Peanut Butter	30g	2 tablespoons
Desserts		
Cake	100g	1 slice
Custard/ Milk-based desserts	130g	½ cup

One exchange in the EP-10 represents 10g of protein and accounts for both protein-rich and non-protein rich foods collectively.

*All quantities are showed in cooked weights and measures unless specified.

Primary Aim and Hypothesis

The primary aim of this study was to assess the relative validity of the EP-10 with the "Exchange List for Meal Planning" developed by the American Dietetic Association (ADA-7g) in quantifying dietary protein intake, against computerised nutrient analysis. It also seeks to investigate the efficacy and reliability of EP-10 relative to the ADA-7g. It is hypothesized that using the EP-10 for dietary assessments would require less time yet produce a similar degree of accuracy as the ADA-7g when compared against the reference method using CNA.

Methods

Study Design and Data Collection

This study was approved by The National Healthcare Group Domain Specific Review Board. It was designed as an equivalence study with at least 192 food records required for 80% power at a 5% significant level in a two-sided paired t-test.

Three-day food records were the focus of analysis for this study. The food records were obtained from a study conducted in Singapore on a convenience sample of healthy adult participants aged 21 and above. All participants were instructed according to the standard protocol of completing 3-day food record. Information recorded in the food records included the type of food, quantity, cooking methods and ingredients where necessary. The food records were verified by a research nurse who underwent six training sessions with a dietician. Completed food diaries were given to a research dietician who made calls to the participants to clarify any further doubts or missing information in the food records**.**

Relative Validity (Protein intake quantification and analysis)

Each of the three daily food records kept by the participants were analysed as a single entity. Protein intake of the food records (n=197) was determined thrice using three different methods as described below.

(1) Expedited 10g Protein Counter (EP-10)
Protein intake was determined from the food records using the EP-10 counter developed as described earlier and shown in Table 2.

(2) *7-grams Protein Exchange Method (ADA-7g)*
The *"Exchange List for Diabetes 2008"* developed by the American Dietetic Association [3] was used to assess the food records using the listed protein exchanges for different food groups including 7g protein exchanges for "meats and meat substitutes".

(3) Computerised Nutrient Analysis (CNA)
Protein intake determined from the food records via computerised nutrient analysis, using the software program SERVE Nutrition Management System for Windows® (Version 4.00P, 2003, M&H Williams Pty Ltd, New South Wales, Australia), was the reference

method in this study. The database was expanded to include local food items. Nutritional information of food items not present in the database were included by extracting the nutrient information from Singapore Food Composition Table,[4] the Nutrient Composition of Malaysian Foods [5] and Bowes & Church's Food Values of Portions Commonly Used.[6] Additionally, the CNA was used to determine the mean energy, carbohydrate and fat intake from the food records.

Protein intake quantification of the food records utilising the EP-10 and the ADA-7g were completed by two dietetic assistants in a blind crossover manner. The two dietetic assistants were trained by a dietician prior to the quantification. A research dietician performed the CNA for all the food records. The dietetic assistants were blind to the results of the latter.

Efficacy (Time taken for protein intake quantification)

The time taken to assess a subsample of the food records (n=165) using the EP-10 and ADA-7g were recorded and compared with each other.

Reliability (Inter-rater reliability)

A repeat assessment of a second subsample of the food records (n=30) was performed by two separate dieticians. The first dietician analysed the food records using the EP-10 and the results obtained are compared to that of the dietetic assistants determined as described above. The same comparison was done by the second dietician who analysed the food records using the ADA-7g. The dieticians were blind to the results of the dietetic assistants as well as the results of the CNA.

Statistical Analysis

All statistical analyses were performed using Statistical Package for Social Science (PASW Statistics, Rel. 18.0.1. 2009. Chicago: SPSS Inc.).

Relative Validity

The mean difference ± SD, linear association and agreement with the CNA were evaluated for both the EP-10 and ADA-7g. Respective results obtained for the EP-10 was then compared to that of the ADA-7g to assess relative validity. The mean difference was evaluated using the paired t-test when the normality assumption was satisfied. Where the latter was not satisfied, the Wilcoxon signed-rank test was used. Linear association was measured by the calculation of the Pearson's correlation coefficient while agreement was evaluated using the Bland-Altman analysis[7] amongst other methods described below.

In the classical Bland-Altman plots, the absolute difference between the values obtained by the two methods of comparison is plotted against the average of the values obtained by the two methods.[7, 8] A trend in bias is a tendency for mean difference to rise or fall with increasing average of values.[9] Where a possible trend in bias was revealed in the classical Bland-Altman plot, a correlation coefficient between the difference and the average was calculated.[9] In addition

to that, a percentage-difference plot was recommended when a trend in bias is seen in a classical Bland-Altman plot.[7, 8, 10] This method was chosen for the interpretation of the results as it would be clinically relevant.

Efficacy

Mean difference ± SD in time taken to assess the subsample of food records using the EP-10 and the ADA-7g was evaluated via a paired t-test to assess efficacy.

Reliability

Mean difference ± SD, linear association and agreement with the respective results of the dietetic assistants were evaluated for the two separate dieticians using either the EP-10 or ADA-7g. Statistical tools for analysis used were similar as those used to evaluate relative validity as described above.

Results

Energy and Macronutrient Intakes

The mean energy intake determined from the food records was 2071 ± 522 kcals, with the mean carbohydrate, fat and protein intakes being 273.7 ± 75.3g, 69.6 ± 30.3g and 101.0 ± 38.9g. Percentage contribution to energy from carbohydrate, fat, and protein were 53.7 ± 10.8%, 29.7 ± 9.3%, and 19.4 ± 5.0% respectively. These energy and macronutrient intake patterns were compatible with the recommended dietary guidelines for Singaporean adults.[11]

Dietary Preferences

Majority of the food records (n=185, 93.7%) revealed a non-vegetarian dietary pattern, with the remaining having no animal sources of protein other than dairy products. Majority of the food records (n=150, 76.1%) did not have nuts or nut products as a contributor towards dietary protein intake.

Relative Validity – Mean differences in protein intake quantification

The EP-10 revealed a statistically non-significant mean difference of 1.4 ± 16.3g (P = .239) when compared to the CNA. The ADA-7g revealed a statistically significant mean difference of -2.2 ± 15.6g (P = .046). Results are shown in Table 3.

Relative Validity – Degree of correlation

Both the EP-10 and ADA-7g demonstrated a very strong correlation with the CNA. Correlation coefficient for the EP-10 was slightly stronger than the ADA-7g when compared to the CNA (r = 0.948 and r = 0.918 respectively, P < .001).

Relative Validity – Degree of agreement with the computerised nutrient analysis

The classical Bland-Altman plots comparing the EP-10 with the CNA and the ADA-7g with the CNA are shown in Figure 1 and 2. The average of protein intakes quantified using the EP-10 and the CNA along with the average of that quantified using the ADA-7g and the CNA both revealed a wide range in protein intakes as shown in Table 3.

Table 3. Mean and mean differences in protein intake quantification of the EP-10, ADA-7g and CNA.

		Results of paired t-test†			
	Mean protein	**Mean difference**	**95% Confidence Interval**		**P-**
Method	**± SD, g**	**(SD), g**	*Lower*	*Upper*	**value**
EP-10	102.4 ± 47.1	1.37 ± 16.3	-.91	3.66	.239
ADA-7g	98.8 ± 37.9	-2.23 ± 15.6	-4.42	-.04	.046‡
CNA	101.0 ± 38.9	–	–	–	–

†Compared with Computerised Nutrient Analysis
‡ Statistically significant (P < 0.05)

For the comparison of EP-10 with the CNA, the correlation coefficient between the difference and average revealed a statistically significant linear association (r = 0.514, $P < .001$). This indicated a trend in bias, as there was a tendency for increased differences between the EP-10 and the CNA as the average of protein intake quantified using these two methods increased. This was also shown by the positive slope of the regression line of difference on average (Figure 1). The trend of bias was not removed despite constructing a percentage-difference plot (Figure 3) and the tendency for increased differences between the EP-10 and the CNA was most notable above average protein intakes of 150g. Out of the 197 food records, 27 (13.7%) food records had average protein intakes above 150g. When the classical Bland-Altman plot was conducted on the food records with protein intakes below 150g (Figure 4), this trend in bias for the EP-10 was not seen. The regression line of difference on average showed a positive slope with a non-significant correlation between the difference and average (r=0.13, P = .109).

A trend in bias was not seen in the classical Bland-Altman (Figure 2) and percentage difference (Figure 5) plots comparing the ADA-7 g with the CNA. For the ADA-7g and the CNA, although the regression line of difference on average showed a negative slope (Figure 2), the correlation between the difference and average was statistically non-significant (r = -0.07, $P = .353$).

Both the EP-10 and the ADA-7g had similar number of food records within the different clinical and statistical limits of agreement as shown in Table 4. Although a majority of the food records were within 95% limits of agreement, some outliers were seen beyond these limits. For the EP-10, most of these outliers had protein intakes above 150g and were above the upper 95% limit of agreement (n=8), rather than below the lower 95% limit of agreement (n=2). On the contrary, most of the outliers for the ADA-7g were below the lower 95% limit of agreement (n=7), rather than above the upper 95% limit of agreement (n=4).

Table 4. Number of food records (and proportion expressed as % of total food records, n=197) within designated limits of agreement

Method	**No. of food records within limits of agreement**					
	± 10g	*± 20g*	*± 2 SD*	*±10%*	*±20%*	*±2SD%*
EP-10	108 (54.8%)	155 (78.7%)	188 (95.4%)	102 (51.8%)	161 (81.7%)	188 (95.4%)
ADA-7g	111 (56.3%)	165 (83.8%)	186 (94.4%)	105 (53.2%)	161 (81.7%)	186 (94.4%)

Efficacy – Mean difference in time taken

The mean time taken to quantify protein intakes from the food records using the EP-10 was significantly shorter than the ADA-7g (65 ± 36 seconds vs. 111 ± 40 seconds, $P < .001$).

Reliability – Mean difference in protein intake quantification

Statistically non-significant mean differences of 3.2 ± 14.3g (95% CI -2.2 to 8.5, $P = .238$) and 1.9 ± 13.9g (95% CI -3.3 to 7.1, $P = .486$) were seen between the different assessors using the EP-10 and the ADA-7g respectively.

Reliability – Correlation between two different assessors

In the interrater reliability test, correlations between the different assessors were both strong for EP-10 and for ADA-7g. Correlation between the different assessors using the EP-10 was slightly stronger (r = 0.970, $P < .001$) than that between those using the ADA-7g (r = 0.959, $P < .001$).

Reliability – Degree of agreement (Bland-Altman plot) between two different assessors

Classical Bland-Altman plots evaluating the inter-rater agreement between the different assessors using the EP-10 and ADA-7g are shown in Figure 6 and Figure 7 respectively. The different assessors using the EP-10 had more food records within the ±10g clinical limits of agreement compared to the different assessors using the ADA-7g (22 versus 20 food records). The assessors using the EP-10 had fewer food records within the ± 20g clinical limits of agreement (26 versus 28 food records) and 95% limits of agreement (27 versus 29 food records) when compared to the assessors in the ADA-7g. For all clinical and statistical limits of agreements, it is noted that the different assessors using the EP-10 differed from the different assessors using the ADA-7g by ± 2 food records, which approximates to 6.7% of the subsample.

Discussion

This study revealed that using the EP-10 for dietary protein intake quantification has clinically acceptable validity and reliability when with the ADA-7 g while requiring less time in an Asian context. In clinical practice, the use of efficient, accurate and practical methods to facilitate assessment and treatment plans is important. This study addresses a crucial step in the dietary assessment of a patient in the clinical setting.

In dietetics, a typical work-flow for the assessment of nutrient intake consists of four main steps – (1) obtaining information of habitual diet intake, (2) quantifying nutrient(s) intake based on the information obtained, (3) making a quick assessment of the diet using evidence-based guidelines and (4) developing a suitable meal plan based on the assessment.[12]
Much research and validation have been performed on various biochemical and dietary methods of protein intake quantification, which fall under the first step of the work-flow.[13-15] Biochemical methods primarily require 24-hour urinary collections, from which urinary concentrations of at least one of the following can be measured to quantify an individual's dietary protein intake – (1) nitrogen; (2) urea nitrogen or (3) nitrogen-to-creatinine ratio.[13, 16] Dietary methods commonly involve dietary surveys which quantify dietary protein intake via nutrient analysis of foods eaten.[17]

However, there is a notable lack of literature and validation studies performed on the second step of the work-flow, which is the analysis of nutrient intake. Validation studies of different dietary surveys commonly use computerised nutrient analysis to quantify any nutrient(s) of interest.[14, 18] Computerised nutrient analysis requires software and the creation of a comprehensive food database tailored to the population of interest. It is often time-consuming and hence, is not practical in clinical practice where steps of the dietetic work-flow occur in quick succession and often in a single sitting. Hence, there is a need for validated and quick methods of dietary assessment for use in clinical settings and the use of exchange lists possesses a large potential to fulfil this. This study validated the EP-10 which has shown to possess considerable efficacy and reliability for use in a clinical setting, thus reducing the gap between published literature and clinical practice.

Validity

When compared to the ADA-7g, the EP-10 has a statistically non-significant mean difference, a stronger correlation and similar degree of agreement with the computerised nutrient analysis. This thereby establishes the validity of the EP-10 relative to the ADA-7g. It is noted that while the mean difference of -2.2g with the computerised nutrient analysis was statistically significant for the ADA-7 g method, it is not considered significant to bring about a clinical difference. Hence, the ADA-7 g method is also an acceptable clinical tool for use in an Asian context.

The resulting EP-10 is tailored for use in the dietetic assessment and recommendation of Asian diets. It includes sources of commonly eaten protein-rich foods and their products as follows: meats, dairy products, beans, legumes, lentils, nuts and selected high-protein starches

and vegetables. The ADA's "Exchange List of Meal Planning" includes all of these foods except nuts and nut products. Nuts and nut products are classified under the category of "fat exchange" and therefore do not contribute towards a protein exchange in the ADA's exchange list.

Even though nuts and nut products do not contribute to any protein exchange in the ADA-7g, the omission has not affected its clinical validity in an Asian context. This may in part be due to the low contribution of nuts and nut products to the protein intake of the food records in this study.

A percentage-difference plot did not reduce the trend of bias seen in the classical Bland-Altman plot for the comparison of EP-10 with the CNA as otherwise suggested.[8, 10] While it is out of the scope of this study to comment on this result mathematically, this persistent trend in bias for the EP-10 holds clinical significance when used to quantify protein intakes above 150g. In the latter, there was a tendency for increasing differences as the average protein intake increased as well as a clustering of most of the large outliers above the upper 95% limit of agreement. This highlights the possibility that the EP-10 has the inclination to overestimate for protein intakes above 150g. The EP-10 method assumes that for every exchange of EP-10, there would also be protein contribution from non-protein rich foods (such as carbohydrates and vegetables). This could be the reason for the overestimation in those with very high protein consumption. However protein intake above 150g per day is uncommon in most population. The Singapore Nutrition Survey 2004 on adults showed that the mean daily protein intake was 83g and 90% consumed between 39 - 133g protein per day.[19] Even in the Americans adults aged 19-30 years who had the highest protein intake, it averaged 91g per day, well below 150g.[20]

This is as opposed to the ADA-7g's possible predisposition of underestimation as most of the large outliers were below the line of equality and lower 95% limit of agreement. Hence, a dietician's individual discretion is important especially when the EP-10 is used for protein intakes above 150g.

Efficacy

In clinical practice, it is a tedious process for dieticians to analyse an individual's diet using different protein exchanges for different food groups. This is supported by the results of this study showing a >40% difference in time taken using ADA-7g compared to the EP-10. The reduction in time taken using the EP-10 shows its efficacy and potentially translates into less time needed when used for dietary assessments and recommendations in clinical practice, which is important especially in resource-poor services.

Reliability

Comparing the EP-10 with the ADA-7g, the number of food records within the different clinical and statistical limits of agreement between the respective pairs of assessors was relatively similar. While the mean difference between the assessors using the EP-10 is numerically higher than that of the ADA-7g, it is not only statistically non-significant but also

clinically non-significant as 3.2g equates to less than half an exchange in the EP-10. Hence, the inter-rater reliability of the EP-10 is acceptable relative to the ADA-7g.

Strengths of the study

This study achieved two firsts – (1) it is the first study to develop a valid and efficient protein exchange list for use in an Asian context and (2) it is the first study to investigate the clinical validity of the ADA's "Exchange List for Diabetes". Measurement bias was reduced with the use of the following – (1) a large sample size with sufficient statistical power, (2) the use of food diaries instead of diet histories as the method of dietary survey, (3) the use of an appropriate reference method of computerised nutrient analysis and (4) the use of the Bland-Altman plot, which is a robust statistical tool for methods comparison. Additional strengths of this study include energy and macronutrient intake patterns of the subjects being similar to recommended dietary guidelines [11] and the blinding of the different assessors, which reduces the verification and review bias.

Limitations of the study and future work

The key limitation of this study would be the use of convenience sampling, hence comprising mostly of Asian diets and only a minority of vegetarian diet. It also includes diets spanning a wide range of protein intakes and a minority of diets having protein intake above 150g. Hence, future validation studies done on non-Asian and vegetarian diets would greatly extend the applicability and feasibility of the EP-10. More work is also needed to affirm the overestimation tendency of the EP-10 and this can be achieved with validation studies concentrating on diets with protein intakes above 150g.

The results of the Bland-Altman method comparing the EP-10 with the CNA revealed a significant correlation between the difference and average of these two methods. A non-zero correlation suggests different variances for the two methods.[9] While a trend in bias is generally the reason for that, a greater measurement error of one method over the other may also cause this difference in variances.[9] It is recommended to evaluate the repeatability of the two methods of comparison to examine the possibility of measurement errors.[9] However, repeatability was not possible for any of the three methods in this study without affecting the blinding of the different assessors. Hence, this is an additional limitation of this study and remains an area to be explored.

Conclusion and Practical Aspects

The development of the EP-10 produced the first protein exchange list developed for use in an Asian context. Compared to their Western counterparts, Asian countries have different dietary habits and the validity of the use of dietary quantification tools in an Asian context have been unknown. The results of this study have shown that both the EP-10 and ADA-7g are valid and reliable tools for use in the quantification of dietary protein, with the EP-10 being more time-efficient, a quality critical in clinical practice and resources-poor settings. However, a dietitian's clinical judgement is needed when the EP-10 is used to quantify protein intakes above 150g.

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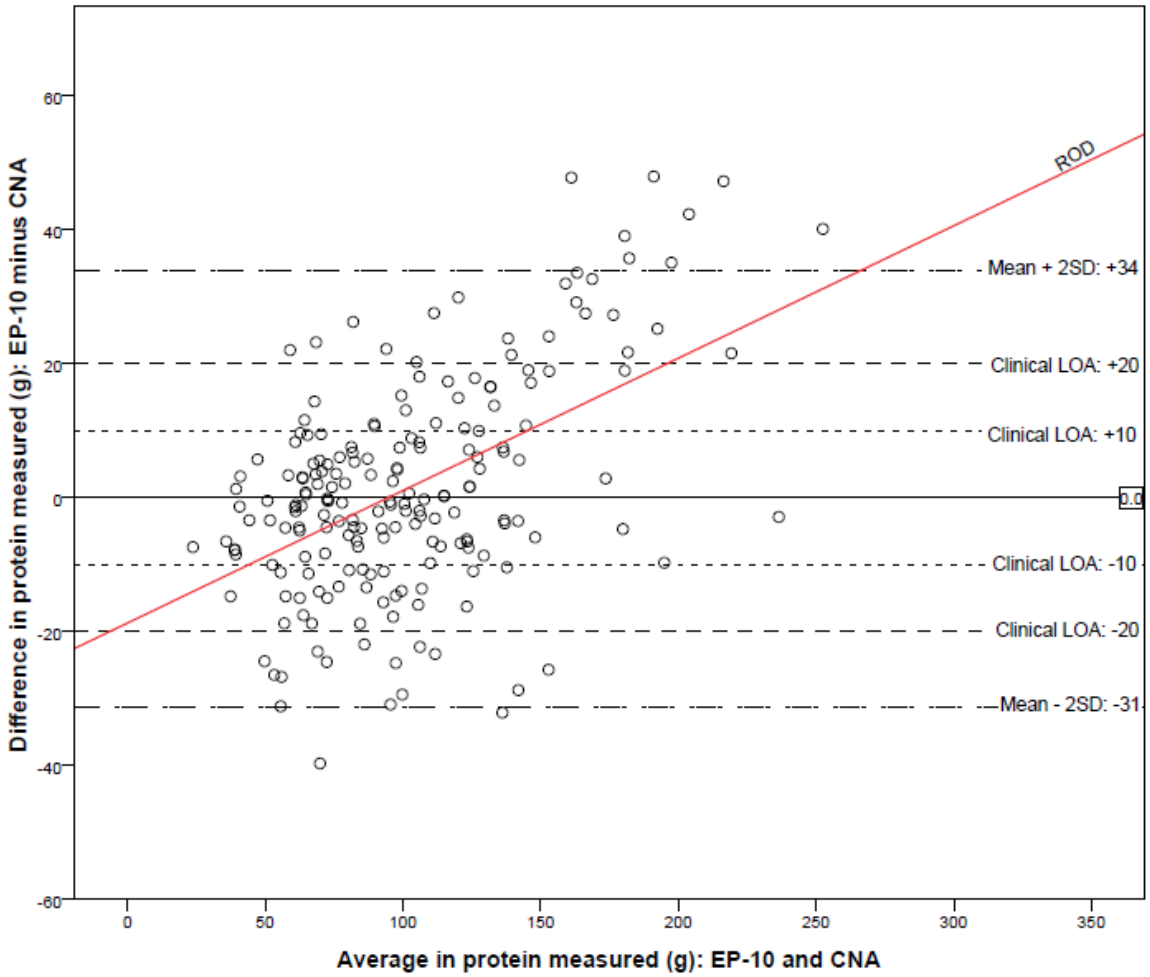
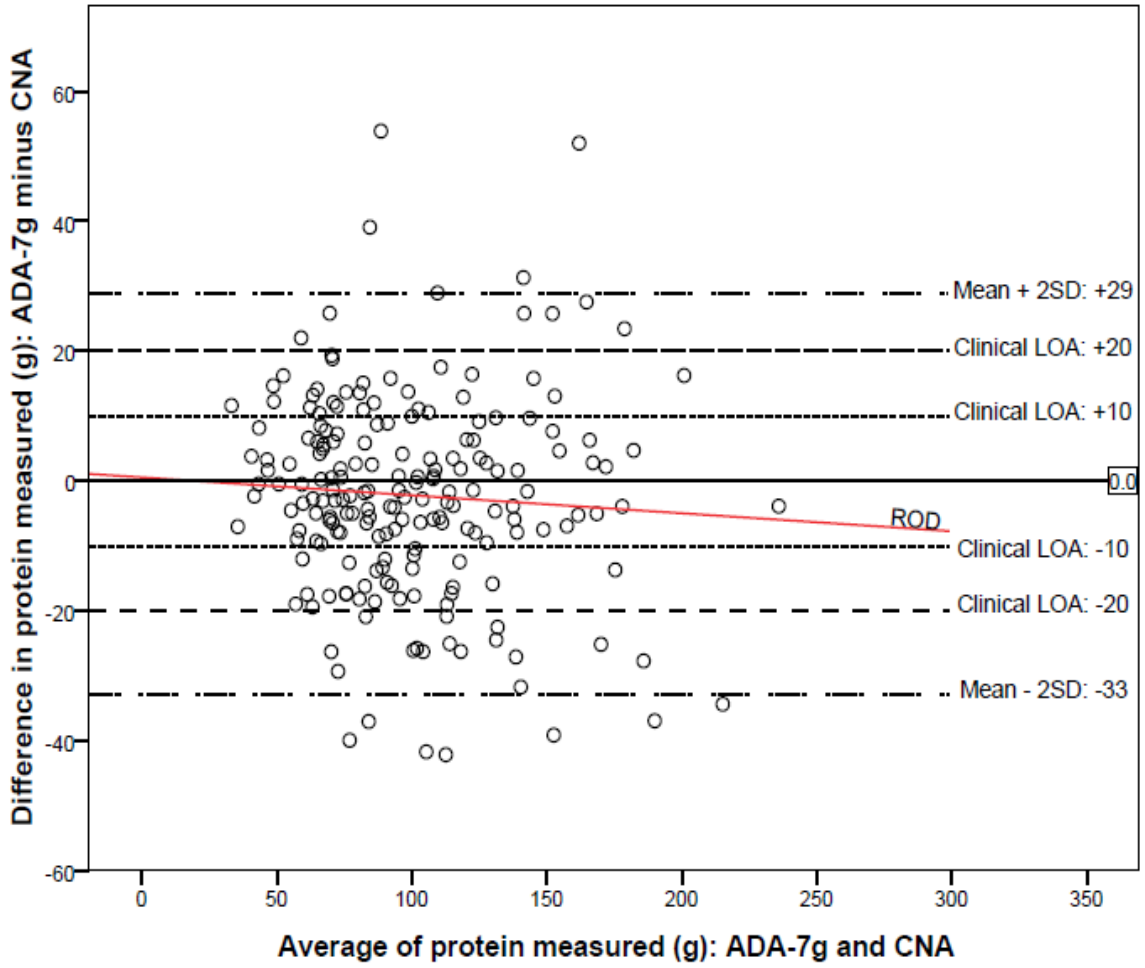
Figure 1. Bland-Altman plot (EP-10 and CNA): The difference in protein intake quantified using the expedited 10g protein counter (EP-10) and the computerized nutrient analysis (CNA) is plotted against the average of protein intake quantified using the EP-10 and CNA.



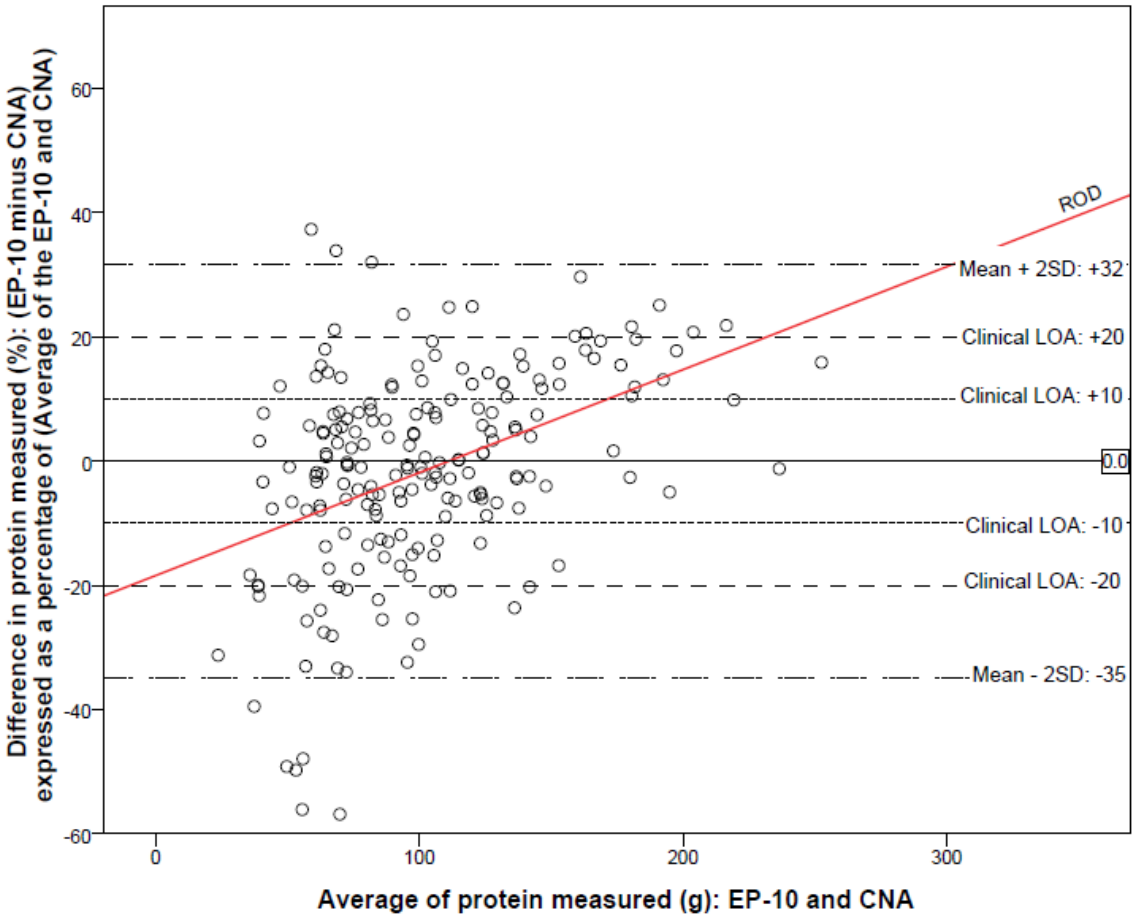
ROD: Regression line of difference on average
LOA: Clinical limits of agreement

Figure 2. Bland-Altman plot (ADA-7g and CNA): The difference in protein intake quantified using the "*Exchange List for Diabetes* 2008" developed by the American Dietetic Association (ADA-7g) and the computerized nutrient analysis (CNA) is plotted against the average of protein intake quantified using the ADA-7g and CNA.



ROD: Regression line of difference on average
LOA: Clinical limits of agreement

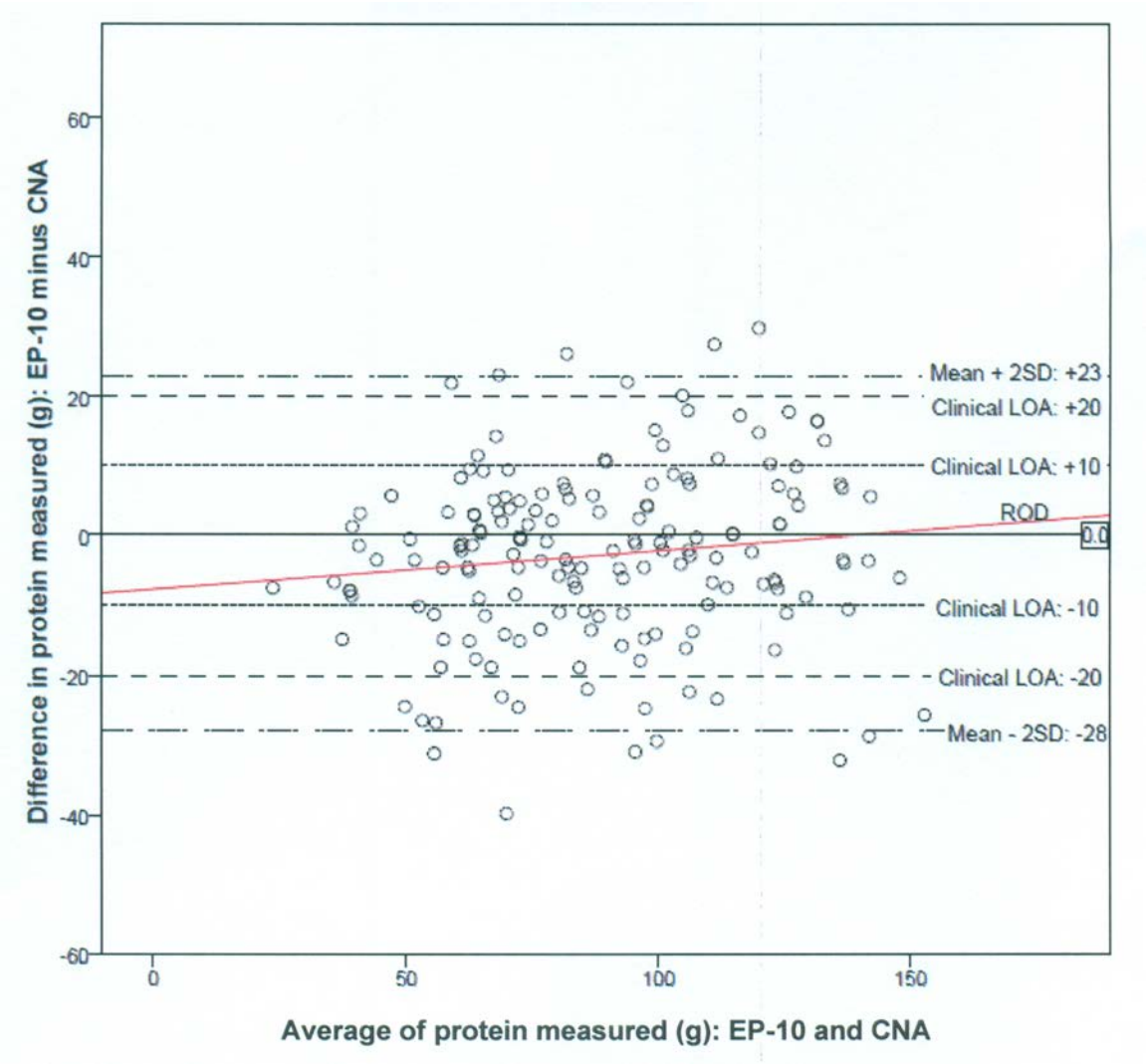
Figure 3. Bland-Altman Percentage Difference Plot (EP-10 and CNA): The difference in protein intake quantified using the expedited 10g protein counter (EP-10) and the computerized nutrient analysis (CNA) expressed as a percentage of the average of protein intake quantified using these two methods is plotted on the y-axis. Plotted on the x-axis is the average of protein intake quantified using the EP-10 and CNA.



ROD: Regression line of difference on average

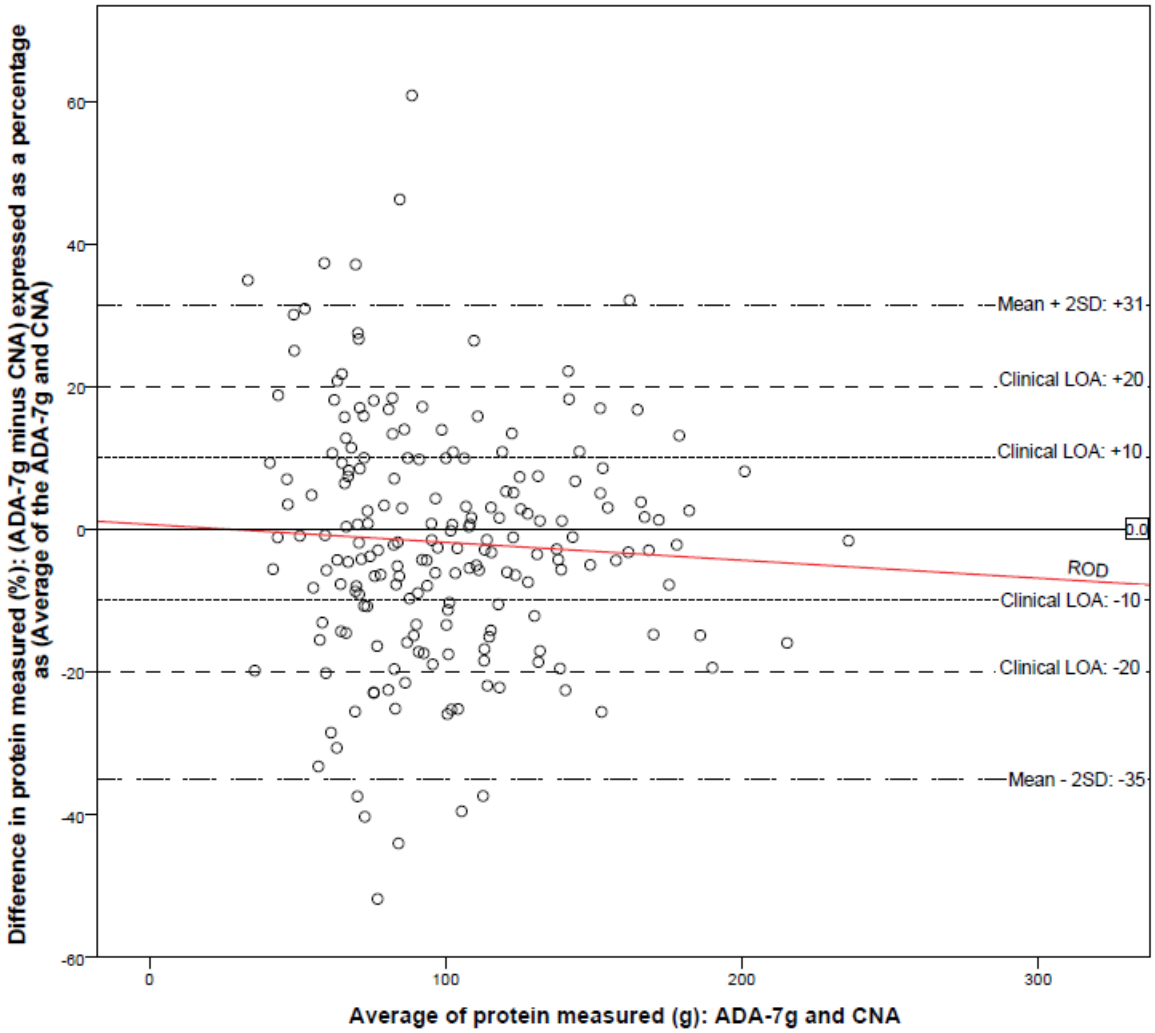
LOA: Clinical limits of agreement

Figure 4. Bland-Altman plot (EP-10 and CNA) excluding intakes above 150g: The difference in protein intake quantified using the expedited 10g protein counter (EP-10) and the computerized nutrient analysis (CNA) is plotted against the average of protein intake quantified using the EP-10 and CAN. Protein intakes above 150g are excluded.



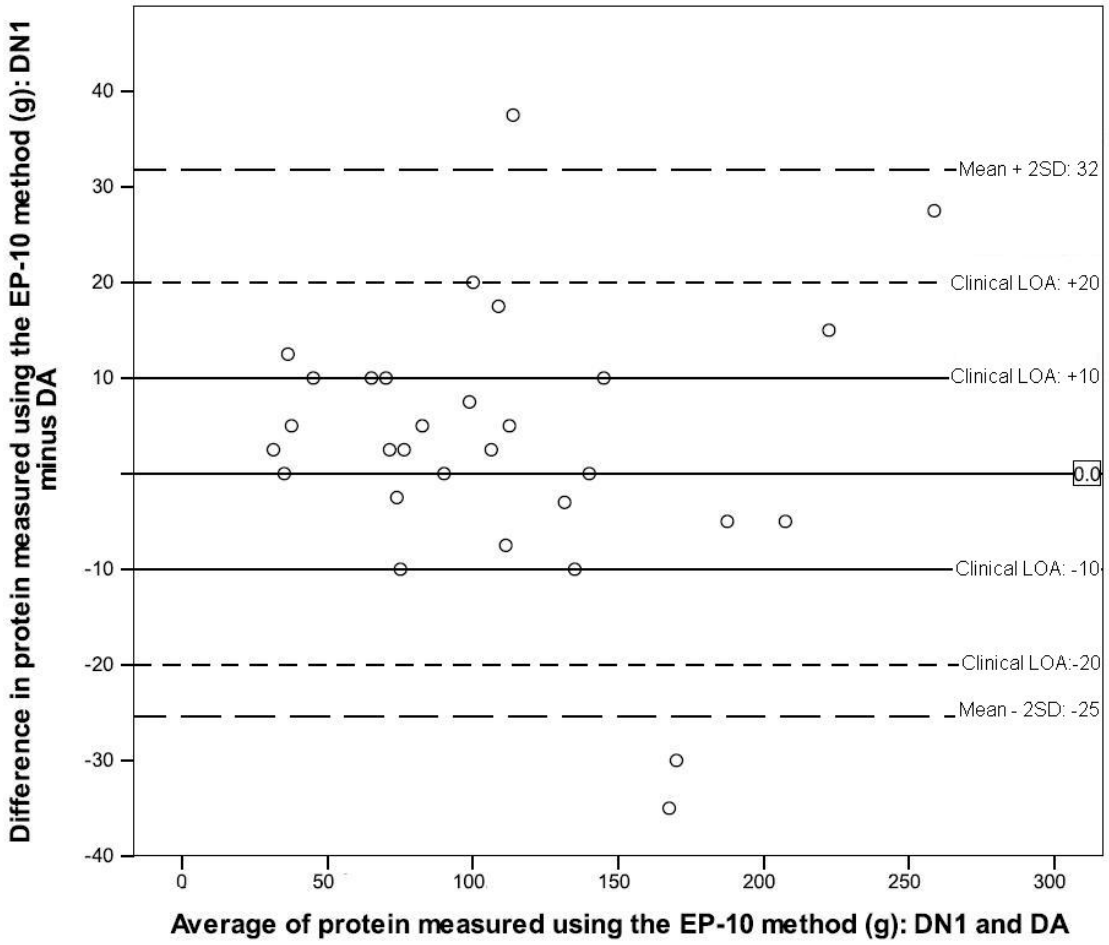
ROD: Regression line of difference on average
LOA: Clinical limits of agreement

Figure 5. Bland-Altman Percentage Difference Plot (ADA-7g and CNA): The difference in protein intake quantified using the "*Exchange List for Diabetes* 2008" developed by the American Dietetic Association (ADA-7g) and the computerized nutrient analysis (CNA) is expressed as a percentage of the average of protein intake quantified using these two methods is plotted on the y-axis. Plotted on the x-axis is the average of protein intake quantified using the ADA-7g and CNA.



ROD: Regression line of difference on average
LOA: Clinical limits of agreement

Figure 6. Bland-Altman Difference plot (Inter-rater reliability of the EP-10): Plotted on the y-axis, is the difference in protein intake quantified using the expedited 10g protein exchange protein counter (EP-10) by two different assessors: the first dietitian (DN1) and the dietetic assistant (DA). The average of protein intake quantified using the EP-10 by these two assessors is plotted on the x-axis.



ROD: Regression line of difference on average
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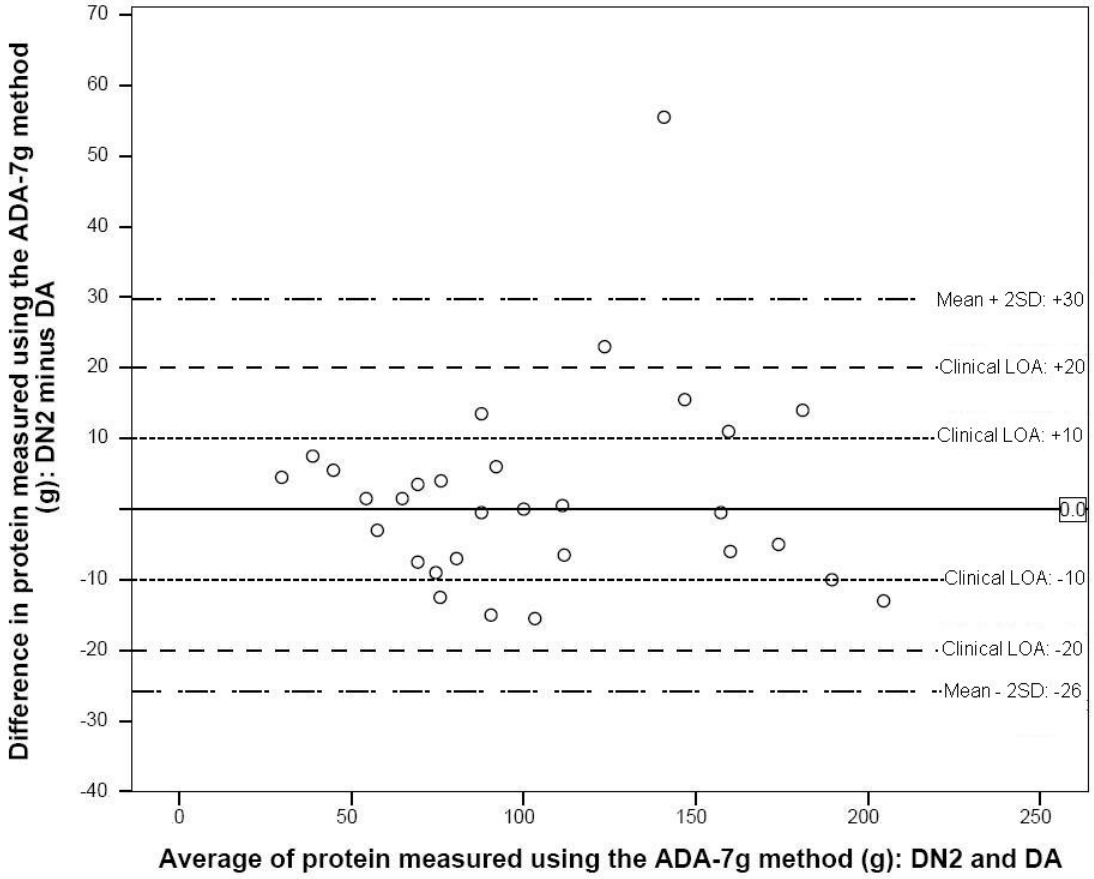
Figure 7. Bland-Altman Difference plot (Inter-rater reliability of ADA-7g):
Plotted on the y-axis, is the difference in protein intake quantified using the *"Exchange List for Diabetes 2008"* developed by the American Dietetic Association *(ADA*-7g) by two different assessors: the second dietitian (DN2) and the dietetic assistant (DA). The average of protein intake quantified using the ADA-7g by these two assessors is plotted on the x-axis.



ROD: Regression line of difference on average
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